Service System Improvements Case Study: Juice Factory

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Abstract

The purpose of this work is to analyze the existing service system based on the Queueing Theory and propose an optimization method. The paper begins with a brief presentation of the store operation, customers and the offered products. In the second chapter, the current service system is described. Hence, the arrival process of customers, clients' behavior, service mechanism and queue characteristics are outlined. These theoretical parts lay the foundation for the mathematical analysis on the efficiency of the current system. In order to investigate the current service system, a practical approach was chosen. This included a two-hours in store observation of the customer buying behavior, cashier responsiveness and service time. The collected data was used for the calculation of Queueing Theory' variables. Based on these results, the next section attempts to describe an optimization system, in form of an electronic device to reduce the waiting time of customers in the queue and increase the utilization rate of the cash desk system.

Keywords 1

Service optimization, customers behavior, choosing aids, waiting time, customer, juice factory

1. Introduction

Juice Factory is a company with currently six stores, three of which are located in Vienna's first district. The stores mainly serve juices and toasted sandwiches, which are prepared freshly and in front of the customer.

The Juice Factory at Schottengasse is located closely to the main building of the University of Vienna as well as to many office buildings. Therefore, the store is especially highly frequented during lunchtime. In all the Juice Factory stores, the on-demand preparation of fresh beverages and food right in front of the customers is very important. Also, an emphasis is put on the interaction between staff and customer. Therefore, a fully automated service system is not wanted.

2. Juice Factory Schottengasse

The shop is equipped with two juicers, two mixers, ciabatta-making station and a gastronomy coffee machine available for the food and beverage preparation at Juice Factory. Furthermore, there is one fully automated cash desk. Figure 1 shows the floor plan of the shop.

IT&AS'2021: Symposium on Information Technologies & Applied Sciences, March 5, 2021, Bratislava, Slovakia
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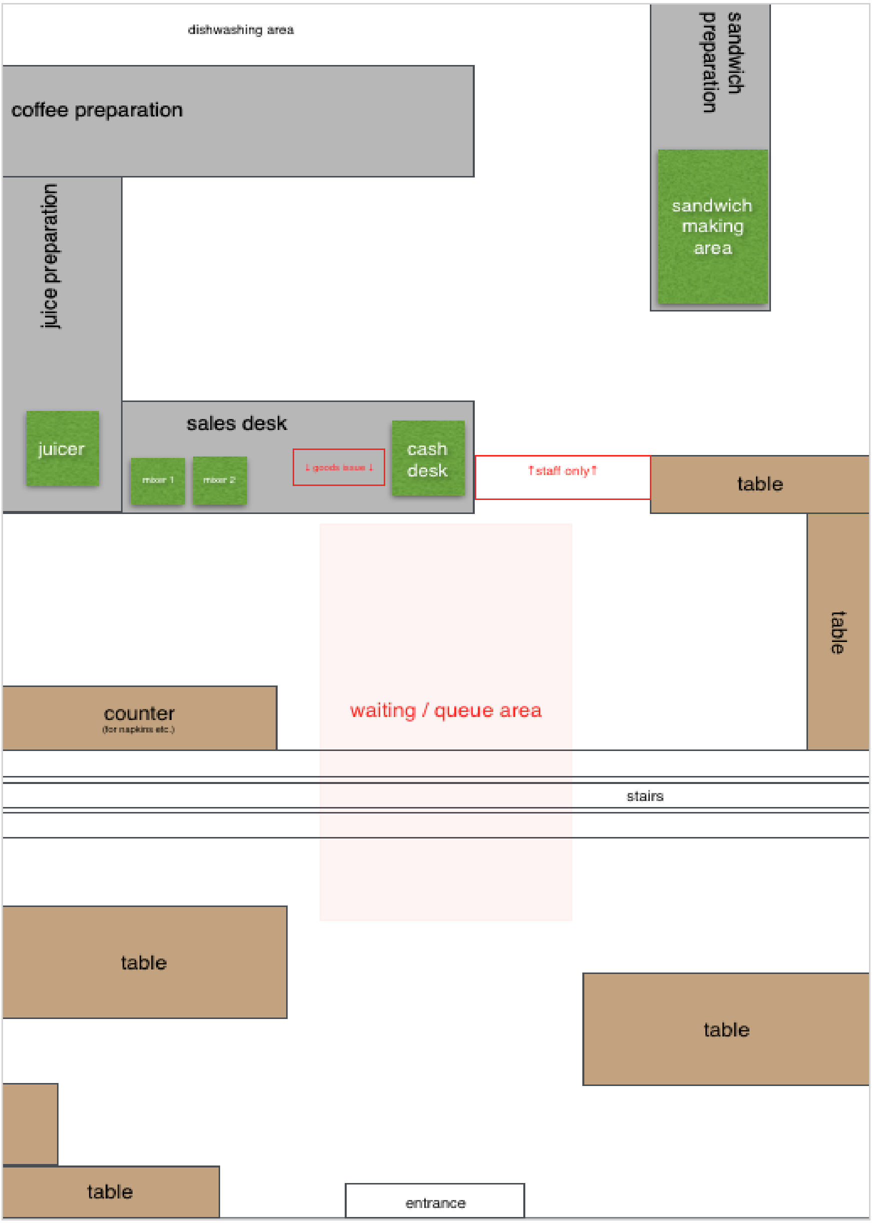

Figure 1: Floor plan of Juice Factory Schottengasse

Due to its location, Juice Factory Schottengasse is frequented by students as well as people working in Vienna's first district. There are many customers that come back daily. These regulars often place the same order every day. On the other hand, there are also many customers who seldomly visit the store or have never been there. These customers tend to take a relatively long time for their purchase decision since there is a wide range of juices to choose from:

Juice Factory offers 23 different Juices that are already pre-divided into the four categories Detox Juices, Fruit Juices, Green Juices and Energizing Juices. The most popular juice is the "Green Machine" which consists of apple, avocado, spinach and lemon. Customers can also purchase freshly made Ciabattas. There are eight different options, including a vegetarian and a vegan one. Furthermore, Juice Factory offers Smoothie Bowls that consist of fruit mousse with toppings like seeds and shredded coconut.

As stated earlier, Juice Factory is most highly frequented during lunch time: In 2017, 41,14 % of turnover was made from 12 - 15h as you can see on Table 1. The busiest day of the week is usually Wednesday, followed by Tuesday, Thursday, Monday and least Friday. Juices are the product group generating most turnover: They make up 60,5 % of the total turnover. Ciabattas generate 19,2 % of turnover, followed by desserts with 9,3 % and coffee with 7,4 %.

Table 1
Timely turnover able

Time	Turnover (%)
7-8	2.00
8-9	7.85
9-10	9.28
10-11	6.96
11-12	9.60
12-13	15.65
13-14	14.93
14-15	10.56
15-16	8.42
16-17	8.03
17-18	5.89
18-19	1.81

3. Description of the Current Service System

Currently, the service in the store follows a first come - first serve principle. Customers come inside the store and form a queue if necessary. The staff member standing at the cash desk takes the order and passes it on to the staff members standing at the juicing or ciabatta making station. Whilst the order is being prepared, the customer pays and then steps aside a little so the next customers can place their order. The ready-made order is given out by the staff member at the cash desk or the juice station or brought to the customer in case he or she decided to take a seat inside Juice Factory.

3.1. Arrival process

At Juice Factory customers arrive both alone and in groups depending on the customer type. For instance, tourists are more likely to arrive in groups than Vienna citizens. The arrival rates of customers are time dependent, as in the lunch time more customers are expected.

3.2. Customers behavior

In summer, the shop usually expects more customers, as the products offered may be more suitable for warmer weather. However, due to the location close to the main university of Vienna, the number of customers significantly decreases during the semester break, as students may be the regular customers. As students or other regular customers know the menu offered, the chances of building queues might be lower chances. By contrast, tourists and new clients may need time to decide and analyze the juices or sandwiches offered leading to possible unnecessary queues.

3.3. Service mechanism

Due to safety requirements, there is a maximum of 40 people allowed in the store. Usually, there are not queues formed until outside of the shop. Juice Factory Schottengasse has five employees: The store manager and assistant store manager, who work full time, a full time employee and two part-time, both working 20 hours per week. The employees work in two shifts: The morning shift starts at 7 am and ends at 2 pm, late shift starts at 11 am and ends at 7 pm. Hence, there is a 3 hour overlap during lunch time where there are four employees in the store. The idea is based on the consideration of peak time, where more customers are expected, and long queues have to be avoided.

Customers can pay either by cash or card. Paying by card may result in shorter overall waiting and, hence waiting time. (In comparison, paying by cash requires customers to search for their money, try to pay exactly or not having enough money, which lead to waiting time and service congestion.).

3.4. Queue characteristics

Customers are served based on the first in first out principle, and there is no priority. The queue has a finite capacity due to the safety requirements and the size of the shop. Moreover, there is only one queue available, so there is no jockeying possible. The queue type is seldom balking, as it usually does not get so long that customers

4. Mathematical Model and Results in the observed Period

In order to analyze the service system at Juice Factory, a field observation was undertaken during peak time. The method was chosen to get more reliable results and investigate possible optimization measures. Hence, the arrival process, the customer's behavior, including consideration time, type of customer, the queue characteristics and the service mechanism were observed. The data were gathered in table A, and the mathematical model and results were summarized in table B.

The observation time was 108 minutes. During this time, each customer arriving at and leaving the shop was monitored. For some customers, more specific data, such as the order, were gathered, whereas for others no estimations were possible due to the limited observation possibilities. The total number of customers observed was 50. Hence, the arrival rate of customers in the shop was calculated according to the formula:

$$\lambda = \frac{50\ cutomers}{108\ minutes} = \ 0{,}462\frac{customers}{minute} = \ 27{,}77\ \ \frac{customers}{hour} \quad (1)$$

In the observed period roughly 28 customers per hour on average visited the shop. As the shop only allows for a maximum of 40 customers due to safety requirements, this number seems plausible. However, as the shop offers only some tables for customers to wait and there are only 4 employees serving, the space could get crowded leading to customers not wanting to enter the shop.

Furthermore, the mean service time was calculated to assess the time needed for the personnel to take the order, prepare it him-/herself or give the preparation to another employee, cash the money and hand the order to the customers.

$$\mu \ = \ \frac{50\ customers}{78\ minutes} = \ 0{,}641\ \frac{customers}{minute} \quad (2)$$

Out of the 108 minutes observation time, within 78 minutes at least one customer was served. We calculated the time by subtracting the overlap between the arrival time and order completion for these single customers. Hence, the server utilization can be calculated as follows:

$$\rho = \frac{\lambda}{\mu} = \frac{0{,}4629\ customers/minute}{0{,}641\ customers/minute} = \ 0{,}722 \quad (3)$$

This means that during 72,2 % of the time observed, at least one customer was served. Consequently, during 27,78 % of the service time the server is idle, which meaning that no employee is serving a customer.

The following formula calculates the mean number of customers in the queue:

$$Lq \ = \frac{\rho^2}{1-\rho} = \frac{(\frac{\lambda}{\mu})^2}{1-(\frac{\lambda}{\mu})} = \frac{0.5215}{0.2778} = \ 1{,}8772 \quad (4)$$

In the observed period, 1.8772 customers were waiting in the queue on average.[2] This leads to mean waiting time per customer of 4.055:

$$Wq = \frac{Lq}{\lambda} = \frac{1.8772}{0.4629} = 4{,}055 \frac{minutes}{customer} \tag{5}$$

and a mean waiting time in the system of 5.6150 minutes:

$$W = Wq + \frac{1}{\mu} = 4.055 \frac{minutes}{customer} + \frac{1}{0{,}641 \frac{customers}{minute}} = 5{,}615\, minutes \tag{6}$$

Based on these calculations, the mean number of customers in the system was calculated with the formula:

$$L = \lambda \cdot W = 0{,}4629 \frac{customers}{minute} \cdot 5{,}6150\, minutes = 2{,}599\, customers \tag{7}$$

Hence, a total of 2.599 customers per minutes was visiting the shop in the observed period. Overview on the initial observation data is presented on Table 2.

Table 2

Overview on the initial observation data and calculations based on these

Observation time	108 minutes
Customers observed	50 customers
Customers per hour	27,77 (28) customers
Arrival rate	$\lambda = \frac{50\, cutomers}{108\, minutes} = 0{,}462 \frac{customers}{minute}$ (= $27{,}77 \frac{customers}{hour}$)
Mean service time	$\mu = \frac{50\, customers}{78\, minutes} = 0{,}641 \frac{customers}{minute}$
(Observed) Time during which at least one customer was served	78 minutes
Server utilization	$\rho = \frac{\lambda}{\mu} = \frac{0{,}4629\, customers/minute}{0{,}641\text{ customers/minute}} = 0{,}722$
Mean number of customers in the queue	$Lq = \frac{\rho^2}{1-\rho} = \frac{(\frac{\lambda}{\mu})^2}{1-(\frac{\lambda}{\mu})} = \frac{0.5215}{0.2778} = 1{,}8772$
Mean waiting time per customer	$Wq = \frac{Lq}{\lambda} = \frac{1.8772}{0.4629} = 4{,}055 \frac{minutes}{customer}$
Mean waiting time in the system	$W = Wq + \frac{1}{\mu} = 4.055 \frac{minutes}{customer} + \frac{1}{0{,}641 \frac{customers}{minute}} = 5{,}615$ minutes
Mean number of customers in the system	L = λ *W = 0.4629 (customers)/minute * 5.6150 minutes = 2,599 customers

5. Opportunities for service optimization

At busy times, relatively long queues form at Juice Factory. This might quench customers who do not want to waste their lunch break waiting in a queue [1-3]. As the process of making food and beverages cannot be further accelerated, an improvement of the ordering system is need in order to improve the whole service system.

Regular customers mostly know already what they want to purchase when they step into Juice Factory. This is different with first-time or non-regular customers: Those often approach the sales desk, overwhelmed by the vast selection of juices which is presented on a big board. Although the juices are already divided into categories to make the choice easier, clients need some time to read through the

[2] The data from the observation complement this calculation: The data set includes the number of customers ahead in the queue of a newly incoming customers. The mean number of customers ahead of a newly entering customer is 0,62. Including the newly entered customer himself, we get a similar number: 0,62 customers waiting ahead + customer himself = 1,62 customers waiting in the queue on average. Since a variation depending on day and time in the observation data is to be expected, the calculated value of 1,8772 will be included in further calculations.

ingredients. The problem is that those customers often feel pressured to make a decision because the staff are awaiting their order. In the case that the customers have to wait in line anyways, the non-regular or first-time customers often still need more time to order than regulars would since they often ask questions or reconsider their choice. This causes the regular customers, which are an important and profitable customer base, having to wait for longer and probably return less often because of this.

5.1. Service Improvement Objective

Consequently, the central objective is to find a way to support non-regulars and first-time customers [4] in making their choice while not losing the customer and staff interaction since it is an important USP for Juice Factory.

5.2. Service System Optimization with a Choosing Aid

A „Quiz“- App can help customers decide for a juice or sandwich and this may help to make the purchase decision process more efficient. A tablet on a stand can be placed on the left end of the sales desk and be indicated with a physical sign. Hence, customer traffic (the queue, respectively) is being divided into first-time or non-regular and regular customers: Regulars stay at the right, first-timers and non-regulars are being led to the left. Consequently, queues during peak times will be shorter. While the regular customers personally place their orders, the first-timers are being guided towards their product choice.

The app asks, for instance, „Fruity or with more vegetables?“, „Uplifter or sweet treat?“ until showing a result that matches the customer’s demand best. Hereafter, they can confirm the result and order or search through other possible matches. To place an order in the app, the customer must click a button to confirm the order and then type her or his name. The staff will be automatically notified that the customers has made a choice and prepare the order. Once the order is finished, the staff will call the customer’s name, issue the goods and finish with the payment. In this way, the personal contact of customer and staff (see Figure 2), an important factor at Juice Factory, does not get lost despite the use of the app.

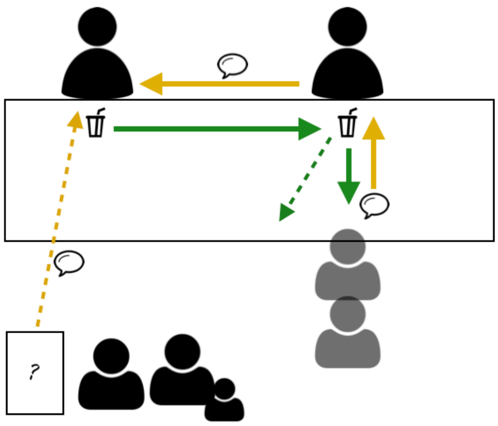

Figure 2: Planned service optimization

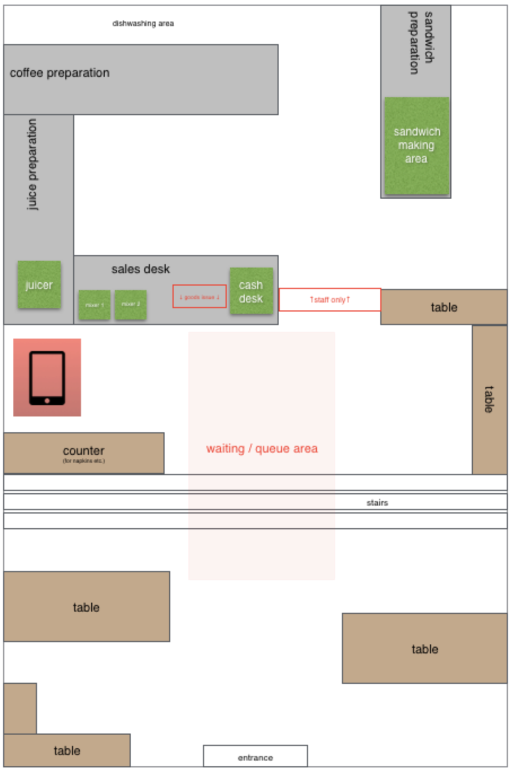

Figure 3: Location of the choosing aid

6. Service efficiency before and after optimization

This chapter analyzes the possible benefits of intruding the app based on the previous calculations and documents received from the store. We hypothesize several changes after service system optimization, which are the base for a renewed calculation of service system measures.

a) Customers per hour and arrival rate

The length queues forming at Juice Factory partly results from the consideration time some customers need. Hence, the service system optimization [5, 6] aims at splitting the queue and thereby making the consideration time less relevant for the queue time. Splitting the "original" queue into an ordering queue (waiting directed towards cash desk) and a consideration queue (waiting for quiz app station) will result in two shorter queues. The ordering queue and, therefore, waiting time as assumed by customers will consequently be lower. Because of this, we expect a lower bounce rate of customers due to long expected waiting time and therefore a higher number of customers per hour:

$$\lambda o = \frac{38\ cutomers}{60\ minutes} = 0{,}633\ \frac{cutomers}{minute}\left[compared\ to\ 0{,}462\ \frac{customers}{minute}\ prior\ to\ optimization\right] \quad (8)$$

b) Consideration time

The consideration time was understood in the model as the time in which the customers were reviewing the menu, asking staff or contemplating about what they should order. As they are waiting in the queue while thinking about the order, they are prolonging the waiting time of other customers. The service system optimization approach [6] splits the consideration time from the queuing time: Since those who need a long time to decide on what to order will be directed towards quiz app station, the consideration time becomes less relevant for the queuing time. According to the observation data, the current average consideration time per customer is 20,46 seconds. After optimization, a consideration time of 5 seconds on average per customer is expected:

$$Consideration\ time\ per\ customer = 5 \cdot \frac{seconds}{customer} =$$

$$= 0{,}83 \cdot \frac{minutes}{customer} \left[compared\ to\ 20{,}46\ \frac{seconds}{customer} = 0{,}341\ \frac{minutes}{customer}\ prior\ to\ optimization\right] \quad (9)$$

c) Mean number of customers in the queue

After service system optimization, the queue will be split into customers who already know what to order and customers who don't who are then being directed at the app station. Due to the changes to the queue, the Lqo calculations priorly made are not applicable anymore! It is expected, though, that the length of the "original" queue can be decreased to only 1 customer waiting in the queue:

$$Lqo = 1[compared\ to\ Lq = 1{,}81] \quad (10)$$

d) Server utilization and mean service time

The results above imply that $Lqo = 1 = \frac{\rho o^2}{1-\rho o}$. The time within which at least one customer was served as observed was $\frac{78\ minutes}{108\ minutes} = 0{,}722\ /\ 72{,}2\%$ of time. This means that within 43,3 minutes out of one hour, at least one customer was served. We assume that after service system optimization, the server utilization can be risen to 50 minutes per hour.

$$\rho o = \frac{50 minutes}{60\ minutes} = 0{,}833 \quad (11)$$

Consequently, the mean service time can be calculated as follows:

$$\rho\text{o} = \frac{\lambda o}{\mu\text{o}} \quad (12)$$

$$\frac{0{,}633\ \frac{cutomers}{minute}}{\mu\text{o}} = \frac{50 minutes}{60\ minutes} \quad (13)$$

$$0{,}633\ \frac{cutomers}{minute} = 0{,}833 \cdot \mu\text{o} \quad (14)$$

$$\frac{0{,}633\ \frac{cutomers}{minute}}{0{,}833} = \mu\text{o} \quad (15)$$

$$\mu\text{o} = 0{,}759 \frac{cutomers}{minute} \quad (16)$$

e) Mean waiting time per customer and in the system

The mean waiting time per customer is expected to decrease:

$$Wq_0 = \frac{Lqo}{\lambda o} = \frac{1}{0.633} = 1{,}58\ \frac{minutes}{customer} *$$

$$\left[compared\ to\ 4{,}055\ \frac{minutes}{customer}\ prior\ to\ service\ system\ optimization\right] \quad (17)$$

Consequently, mean wait in the system decreases, too:

$$Wo = Wqo + \frac{1}{\mu\text{o}} = 1 + \frac{1}{0{,}759\ \frac{cutomers}{minute}} =$$

$$= 2{,}32\ \text{minutes}\ [compared\ to\ W = 5{,}615\ prior\ to\ service\ system\ optimization] \quad (18)$$

f) Changes of number of customers in the system

Due to less waiting time and higher service rate, the mean number of customers in the system decreases:

$$Lo = \lambda o \cdot Wo = 0{,}633 \frac{cutomers}{minute} \cdot 2{,}32\ minutes =$$

$$= 1{,}468\ [customers\ compared\ to\ 2{,}599\ prior\ to\ service\ system\ optimization]. \quad (19)$$

Table 3
Overview on the initial observation data versus improvements after service

	As observed	After optimization
Customers per hour	**28 customers**	**38 customers**
Arrival rate	$\lambda = \frac{50\ cutomers}{108\ minutes} = 0{,}462\ \frac{cutomers}{minute}$	$\lambda_o = \frac{38\ cutomers}{60\ minutes} = 0{,}633\ \frac{cutomers}{minute}$
Consideration time per customer	$20{,}46 \cdot \frac{seconds}{customer} = 0{,}341 \cdot \frac{minutes}{customer}$	$5\ \frac{seconds}{customer} = 0{,}83\ \frac{minutes}{customer}$
Mean number of customers in the queue	$Lq{=}1{,}81$	$Lqo = 1$
Time within at least one customer is served per hour	43,3 minutes	50 minutes
Server utilization	$\rho = 0{,}722$	$\rho o = 0{,}833$
Mean service time	$\mu = 0{,}641\ \frac{customers}{minute}$	$\mu o = 0{,}759\ \frac{cutomers}{minute}$
Mean waiting time in the system	$W = 5{,}615\ minutes$	$Wo = 2{,}32\ minutes$
Mean waiting time per customer	$Wq = 4{,}055\ \frac{minutes}{customer}$	$Wqo = 1{,}58\ \frac{minutes}{customer}$
Number of customers in the system	$L = 2{,}599\ customers$	$Lo = 1{,}468\ customers$

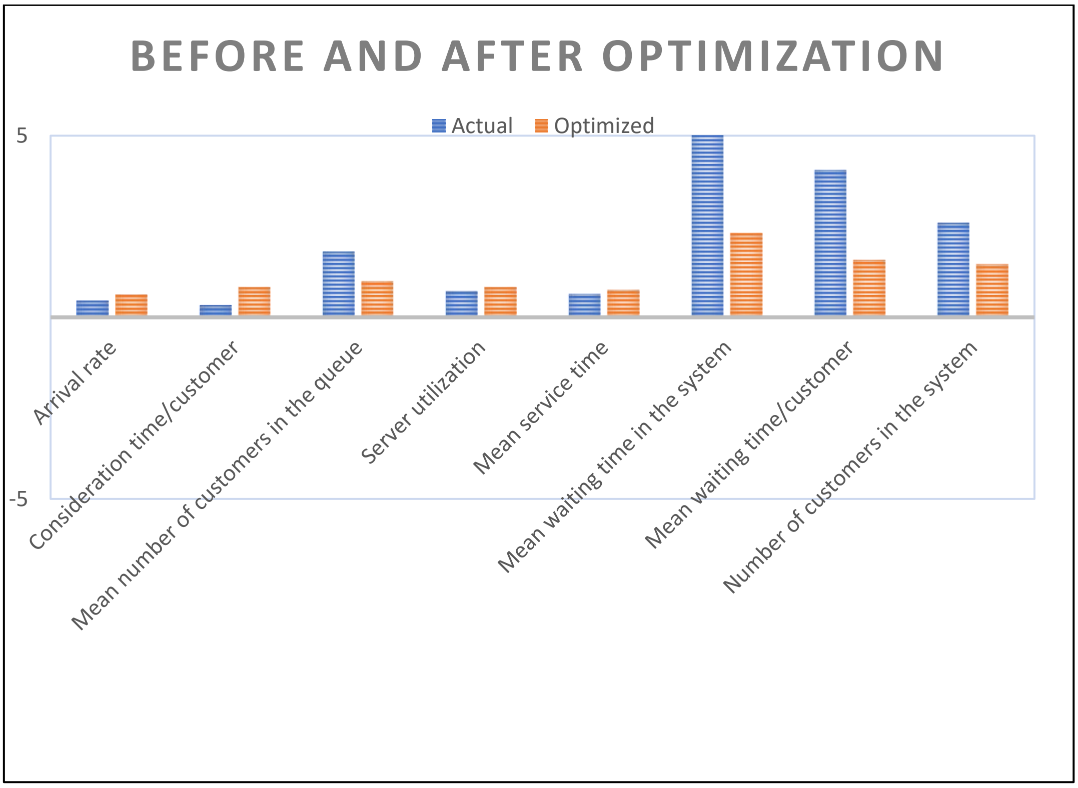

Figure 4: Illustration of main results

7. Conclusion

In this paper, we conducted a field observation of the service system at Juice Factory, Schottengasse from Vienna. The results of the actual queuing characteristics combined with the analysis of internal documents [7], provided us with the opportunity to study an optimization mechanism [8-12]. Hence, we analyzed the hypothetical situation of introducing an electronic device to reduce the waiting time of customers in the queue [13-15]. The rationale behind this decision was to differentiate between regular and first-time customers in order to subtract the consideration time from the waiting time. By doing so, first time customers are directed to the app and do not hold others in the queue while studying the menu.

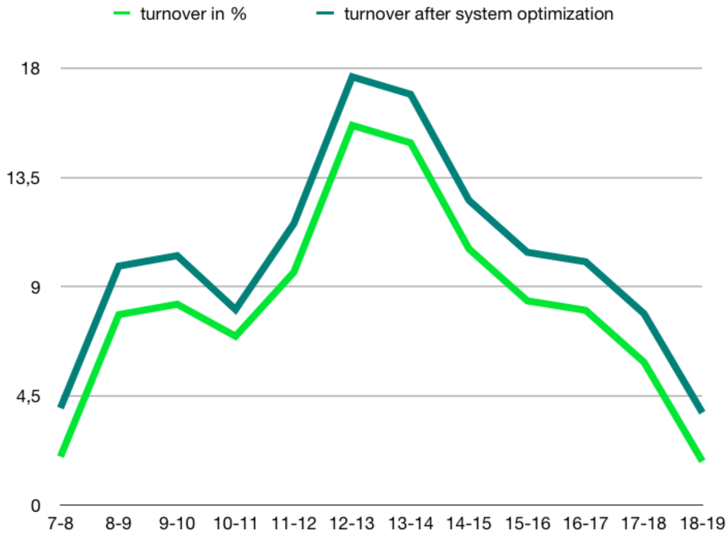

Figure 5: Expected turnover rates

As stated above, this service system optimization is expected to bring significant improvements at Juice Factory, including, most importantly, more customers per hour and a higher server utilization rate [22-24]. These two factors are, furthermore, directly linked to turnover increasing the efficiency of the service provision (Figure 5).

A limitation of this work is the hypothetical nature of the provided results after the optimization attempt with the electronic device. In order to gather real time data, one would have to analyze the service system after such an implementation, however the management of the shop does not yet consider switching to electronic devices [26]. As they provide customer service at the cashier desk, they have the possibility to interact with the customer and pursue them into buying extra sandwiches of juices. By contrast, the device would only satisfy wishes and reduce the social interaction with the staff [27-29].

Despite this limitation, the introduction of an electronic app has proved to be efficient in shops, such as McDonald’s, leading us to believe that such a device would be beneficial also for Juice Factory.

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